2013

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Jerome K. Vanclay
Southern Cross University

Publication details

Preprint of: Vanclay, JK 2013, 'Factors affecting citation rates in environmental science', *Journal of Informetrics*, vol. 7, no. 2, pp. 265-271.
Published version available from:
http://dx.doi.org/10.1016/j.joi.2012.11.009

Journal of Informetrics 7(2):265-271 (2013) http://dx.doi.org/10.1016/j.joi.2012.11.009

Factors affecting citation rates in Environmental Science

Jerome K Vanclay
Southern Cross University, PO Box 157, Lismore NSW 2480, Australia
jvanclay@scu.edu.au

Abstract

Analysis of 131 publications during 2006-07 by staff of the School of Environmental Science and Management at Southern Cross University reveals that the journal impact factor, article length and type (i.e., article or review), and journal self-citations affect the citations accrued to 2012. Authors seeking to be well cited should aim to write comprehensive and substantial review articles, and submit them to journals with a high impact factor which has previously carried articles on the topic. Nonetheless, strategic placement of articles is complementary to, and no substitute for careful crafting of good quality research. Evidence remains equivocal regarding the contribution of an author's prior publication success (h-index) and of open-access journals.

Key words: Citedness, journal impact factor, research impact

Introduction

Consistent with common convention, many academics are advised to publish their work in open-access journals with a high impact factor (e.g., Van Teijlingen & Hundley 2002, Rowlands et al 2004). The dominant indicator of journal standing, the Thomson-Reuters impact factor has been subject to some criticism (e.g., Rossner et al 2007, Vanclay 2012), and it is interesting to examine the extent to which it influences citation rates. Thus this paper seeks to examine the influence that the Thomson Reuters impact factor (TRIF), author h-index and other factors have on citation rates of journal articles in the environmental sciences.

This study sought to create a predictive model to test the assumption that the importance of impact factor was over-rated, and that other factors such as author h-index and open-access were also influential. Thus the null hypothesis was that citation rate was unaffected by TRIF, author h-index, type of the article (article or review), open access and other factors, and the initial expectation was that empirical evidence would lead to the rejection of this hypothesis for some (e.g., h-index and open access) but not all of these variables (e.g., TRIF, author surname). However, the results were surprising.

Literature

Others have examined similar questions surrounding the rate at which scientific articles accrue citations, partially if not unequivocally. Several researchers (Antelman 2004, Eysenbach 2006, MacCallum and Parthasarathy 2006) have reported that articles in open-access journals have greater impact, but others (e.g., Craig et al 2007, Gaule and Maystre 2011) discounted this effect. The utility of TRIF as a predictor of citation rates is equivocal: Judge et al (2007) reported that "the single most important factor driving citations to an article is the prestige or average citation rate of the journal in which the article was published", and this view is supported by subsequent studies (e.g., Larivière and Gingras 2010, Mingers and Xu 2010, Peng and Zhu 2012), but Seglen (1994) differed in concluding that "the citedness of journal articles thus does not seem to be detectably influenced by the status of the journal in which they are published". Leimu and Koricheva (2005a) also discounted the effect of TRIF, and attributed citation rates to scientific findings (supportive versus unsupportive evidence), article length, number of authors and affiliation. Many commentators are unhappy that the correlation between TRIF and mean citation rates leads some to use the TRIF for a proxy for article quality, pointing to flaws in the TRIF (e.g., Rossner et al 2007, Seglen 2007, Vanclay 2008, 2012) and other shortcomings (e.g., Seglen 1992, 1998). Several groups have observed that multi-author papers are cited more frequently than single-author articles (e.g., Smart and Bayer 1986, Katz and Martin 1997, Leimu and Koricheva 2005b, Figg et al 2006, Hsu and Wang 2011), but this observation is not universally supported (e.g., Bornmann et al 2012). Di Vaio et al (2012) suggested that the optimal article for citation success has 30 pages and two authors. Vieira and Gomes (2010) reported that both the TRIF and the number of references had a substantial and linear effect on citation rates.

Many studies of citation patterns are confined to restricted samples (e.g., Kulkarni et al (2007) who examined citations to articles in three journals). The present study is more diverse, dealing with publications during 2006-07 by all members of the (then) School of Environmental Science and Management at Southern Cross University, a team embracing marine, terrestrial and arboreal interests (Lloyd et al 2011).

Data

Publications by staff in the School of Environmental Science and Management formed a useful cohort to study because of the disciplinary breadth represented (Lloyd et al 2011) and the ability to verify all publications and author identities. The period 2006-07 was chosen because it predates coaching in publication strategy, and allows sufficient time for articles to reveal their merit in ecological fields that are slow to accrue citations (Vanclay 2009). Scopus is the official data provider to the Australian Government's research evaluation (Excellence in Research for Australia, e.g., Vanclay 2011), so was used as the basis for counting publications by, and citations to the 57 individuals who were staff or adjuncts of the School, either then (during 2006-07) or now (in 2012). The analysis drew on all publications classified by Scopus as articles, conference papers, or reviews (i.e., editorials, short surveys, and letters to the editor were omitted), in journals assigned an impact factor by Thomson Reuters – a total of 131 items spanning a wide range of topics and journals (Table 1).

Table 1. Summary of Journals in study

Journal or Field	Articles	Average TRIF
Forest Ecology and Management	14	1.84
Coral Reefs	9	2.20
Geochimica et Cosmochimica Acta	6	3.75
Marine Ecology Progress Series	5	2.29
Environmental Science and Technology	4	4.04
Aquaculture	4	2.08
Marine Biology	4	1.76
Oil and Gas Journal	4	0.03
Other ecology	18	2.86
Other interdisciplinary	14	1.22
Other marine and aquaculture	12	1.96
Other zoology	11	1.40
Geochemistry and chemistry	10	1.39
Geomorphology and geology	6	1.49
Other soil science	5	1.21
Other forestry	5	1.08
Total (72 journals)	131	1.93

Table 2 summarises the variables explored in this study. Two-year impact factors for 2006 were derived from the Thomson-Reuters Web Journal Citation Reports. The Hirsch (2005) h-index was used as a proxy for author experience, and was obtained for all authors using Scopus, constrained to estimate the h-index as at end 2006 based on citations received 1996-2006. This study employed both the h-index of the first author, and in the case of multiple authors, of the author with the highest h-index.

Journal self-citation has been examined by several researchers examining manipulation of the impact factor (e.g., Seglen 1997), but non-gratuitous journal self-citation may also indicate whether a contribution is well-placed within its discipline (e.g., Knight and Steinbach 2008) – thus the number of journal self-citations is included in Table 2, and considered as a novel predictor of the rate at which an article accrues citations. It is envisaged that moderate journal self-citation may indicate that an article is well-suited to a journal (cf. "Right kind of reader", Rowlands et al 2004).

Since review articles may be cited more often (Ketcham and Crawford 2007), it is important to discriminate review articles from other contributions (articles and conference papers), and this distinction was based on the Scopus classification and the article title. Article length was based on published pages, uncorrected for page or font size. Open access was coded as a ternary variable, with zero for subscription-based, one indicating free versions (such as preprints) visible to Google Scholar, and two indicating an open-access journal (e.g., amongst present data, *Ecology and Society*).

Year of publication was included in the analysis, but is assumed to be of little consequence since the dependent variable was corrected for time since publication (i.e., cites per year). Finally, the first letter of the first author's surname was coded (1-26), since there are some reports (e.g., Einav and Yariv 2006, Van Praag and Van Praag 2008) that first author surname may influence citation rates (i.e., that A-authors may be cited more frequently than Z-authors). These data are summarised in Table 2.

Table 2. Summary of data (n=131).

	Data range				Mean within quartile (ranked by cites/year)			
Variables	Min	Mean	Median	Max	Q1	Q2	Q3	Q4
Ln(1+Cites/yr)	0	1.2	1.2	4.3	2.1	1.4	1.0	0.4
Cites/year	0	3.5	2.2	69.7	9	3	2	1
Total Cites	0	19.5	12	418	48	17	10	3
Impact factor (TRIF)	0	1.9	1.8	5.6	2.6	2.2	1.8	1.0
Max(h-index)	0	11.8	12	39	15	14	13	6
Journal self-citations	0	3.6	2	33	6	4	3	2
Review article	0	0.1	0	1	18%	9%	3%	6%
Article length (Pages)	1	10.7	10	31	12	11	10	9
Number of Authors	1	3.7	3	36	4.5	4.3	3.4	2.7
First h-index	0	4.1	3	18	5	5	4	3
Open access	0	0.4	0	2	52%	39%	61%	31%
Year published	2006	2006.5	2006	2007	2006.4	2006.6	2006.5	2006.3
First letter	1	11.2	12	26	10.8	10.9	10.5	12.5

The within-quartile averages shown in Table 2 clearly indicate that some variables exhibit a strong relationship with the citation rate. This is further elucidated in Table 3 which illustrates the Pearson correlations between the principal variables. Table 3 displays four columns, the preferred dependent variable Ln(1+Cites/yr), its untransformed equivalent (Cites), and two explanatory variables (TRIF, h-index) which enable readers to appreciate correlations between variables (e.g., 0.55 between TRIF and h-index).

Table 3. Pearson correlations between selected variables (n=131).

	Correlation with			
Variables	Ln(1+Cites/yr)	Cites	TRIF	Max(h-index)
Ln(1+Cites/yr)	1	**0.69**	**0.56**	**0.42**
Total Cites	**0.69**	1	**0.42**	**0.33**
Impact factor (TRIF)	**0.56**	**0.42**	1	**0.55**
Max(h-index)	**0.42**	0.33	**0.55**	1
Journal self-citations	**0.31**	0.10	0.15	0.17
Review article	**0.30**	**0.35**	-0.02	0.06
Article length (Pages)	0.29	0.23	0.09	0.22
Number of Authors	0.21	0.20	**0.34**	**0.36**
First h-index	0.18	0.19	0.00	0.14
Open access	0.17	0.14	0.17	0.18
Year published	0.04	-0.08	-0.03	0.04
First letter	-0.06	-0.11	-0.06	0.06

Method

Table 3 indicates Pearson correlations between the potential explanatory variables and the observed citation rate. The strongest correlation (r=0.56) was exhibited by the impact factor (Figure 1).

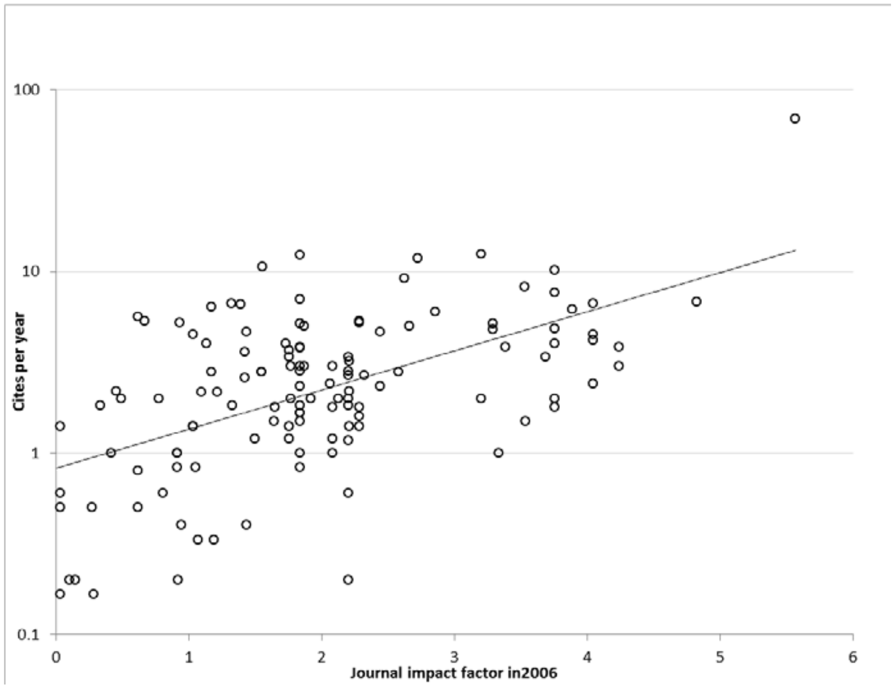

Figure 1. Journal impact factor exhibits a strong correlation with citation rate. (Five uncited articles have been omitted from this graph to allow a logarithmic scale to be used).

There is also a high correlation between some of the explanatory variables such as the impact factor and the author h-index (Figure 2), and it appears that experienced authors are less likely to submit material to journals with lower impact factors (Figure 2).

Figure 2. Relationship between author h-index and journal impact factor.

One of the challenges in analysing these data is that many of the variables are auto-correlated (Table 3), and that, for instance, it is unclear whether high citation rates are due to one variable (e.g., TRIF) or another (e.g., author h-index). Linear regression analyses were used to simultaneously estimate the influence of the variables under consideration (Table 1). Large heteroscedacity indicated the need for a logarithmic transformation, and one anomalous point with a large Cooks distance (>0.4, Kim and Storer 1996) was omitted, leaving 130 data for analysis.

Regression analyses employed stepwise linear regression (Derksen and Keselman 2011) with the conventional P=0.05 selection criterion. The best model, with an r-squared of 0.45, was

$$\mathrm{Ln}(1+\mathrm{Cites/year}) = 0.410 + 0.777\ \mathrm{Ln}(\mathrm{TRIF}+1) - 0.0821/\mathrm{Pages} + 0.483\ \mathrm{Review} + 0.025\ \mathrm{Jself} \qquad (1)$$

where *TRIF* is the Thomson-Reuters 2-year impact factor (2006), *Review* is a binary variable (0,1) indicating if the article is a review, *Jself* is the number of journal self-citations amongst the citations, and *Pages* is the length of the article (uncorrected for page or font size). All parameter estimates were significant at P<0.01 (Table 4). Other parameters such as author h-index and open access were not significant with or without transformations.

Table 4. Model Parameters estimated for Equation (1).

Variable	Estimate	Std. Error	Student's t	P
Constant	0.410	0.117	3.50	0.0006
Ln(TRIF+1)	0.777	0.104	7.47	<.0001
1/Pages	-0.821	0.230	-3.57	0.0005
Review	0.483	0.150	3.22	0.0016
Jself	0.025	0.009	2.68	0.0083

The high correlation between TRIF and author h-index may potentially obscure a relationship, so an attempt was made to create a model which omitted TRIF and relied on h-index, but the best such model achieved an r-squared of only 0.28, with a fit markedly inferior to that reported in Table 4. It seemed possible that some variables might interact, and that lengthy review articles might attract additional citations, but no interaction terms (e.g., *Review/Pages or Open.TRIF*) were found to be significant.

Table 5 reveals the partial correlations of the unused variables after fitting equation (1), and confirms the absence of other trends. There is a slight tendency for articles published in 2007 to be cited more frequently, but this is not significant (P>0.1). Similarly, there is a slight but non-significant tendency for citations to increase with the h-index of the first author. However, there is no evidence in the present data that open-access leads to higher citations, that the alphabetical position of the first author has an effect, or that the number of authors is influential.

Table 5. Partial correlations after fitting equation (1) – all non-significant (P>0.10).

Variables	Partial correlation
Year published	0.13
First h-index	0.08
Open access	-0.06
First letter	-0.04
Max(h-index)	0.00
Number of authors	0.00

Results

Table 6 summarises the implications of Equation (1). It predicts that an article with characteristics of the lowest decile (i.e., a 5-page article in a journal with impact factor 0.3) is likely to gain 0.6 cites/year, a citation rate corresponding to the lowest decile amongst global contributions to the 72 journals included in this study. An article with characteristics near the median (10 pages, TRIF 3.7) is likely to attract 2 cites/year, a three-fold increase in citation, boosting recognition into the top 60% globally. And a contribution reflecting the top decile (e.g., an 18-page review article with 10 references to its host journal with TRIF 3.7) is likely to attract 9 cites/year, placing it within the top 9% globally within these fields. Evidently, relatively small changes in publication strategy may influence substantial changes in the expected citation rates. Equation (1) applies to a particular research team during 2006-07 (albeit a team with a profile rather close to the global pattern at that time, Figure 3), and will not apply universally, so the utility of the equation arises from the relative numbers, not the absolute values of estimated citations.

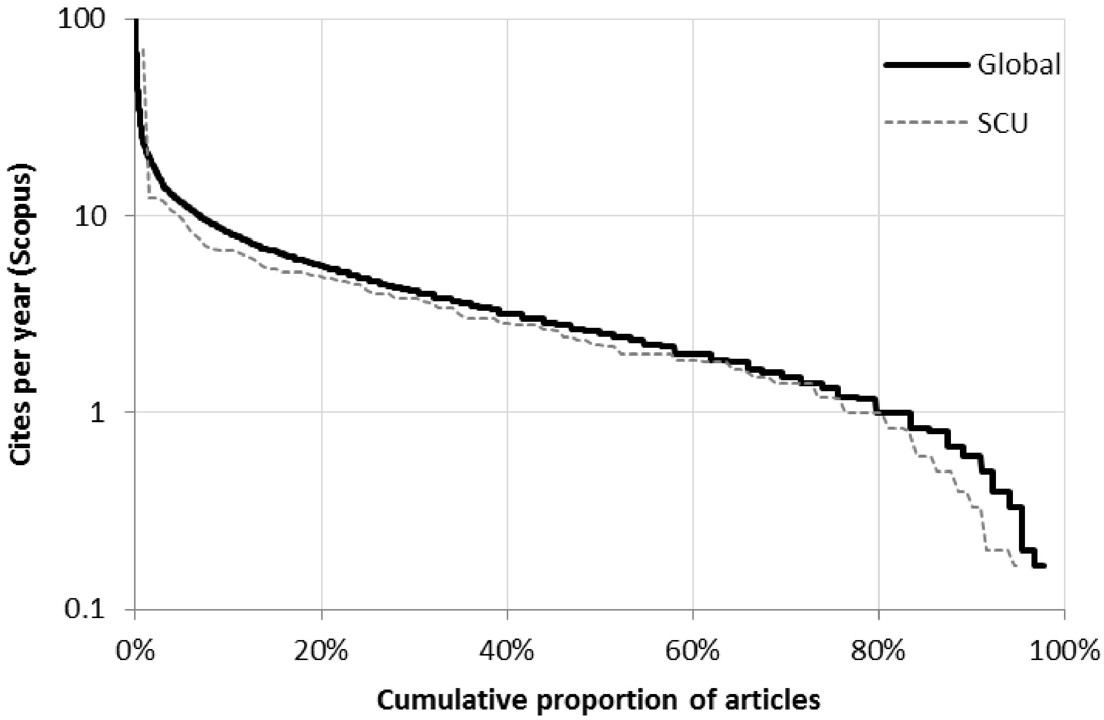

Figure 3. Citations and global ranking of articles in 72 journals during 2006-07.

Table 6. Predicted increase in citations accruing to modelled variables

Variable	Lowest Decile (90%)	Median (50%)	Highest Decile (10%)	Expected cites/yr	
				90% to Median	Median to 10%
TRIF	0.3	1.5	3.7	1.6	3.8
Pages	5	10	18	0.7	2.1
Review	0	0	1	(no change)	3.9
Jself	0	2	10	0.7	2.7
Predicted cites	0.6	2.0	8.9		
Global context	90%	60%	10%		

The rightmost columns of Table 6 illustrate the changes in citation rate accruing from an increase in a single variable. Thus for instance, successfully diverting a manuscript characteristic of the lowest decile from a journal with a low TRIF (0.3) to one with a higher impact (1.5) raises the expected citation rate from 0.6 to 1.6 cites/year, raising its rank from the lowest decile (90%) to the next quartile (70%). And revising a manuscript characteristic of the median and enhancing it as a comprehensive review may increase the expected citation rate from 2.0 to 3.9 cites/year, raising the ranking from 60% to 32%. It is evident that the variables that promise the greatest citation success are the journal impact factor and review articles.

Discussion

In short, publishing in a journal with a higher impact factor appears to be the most effective strategy to increase citation rates. Articles in top-ranked journals such as *Nature* were not included in the calibration of Equation (1), so predictions for high-impact journals need to be made with caution, but the prediction is that a short contribution to *Nature* (2006 TRIF = 26.7) could achieve 14 citations per year, which would place it within the top 3% globally. Readers familiar with critiques of the TRIF (e.g., Vanclay 2009, 2012) may be surprised at these findings, but the evidence is clear, and it is evident that the journal impact factor is a good concept, albeit with some weaknesses in implementation.

The number of journal self-citations is moderately influential, and this should be seen as the desirability of publishing within a journal where a conversation is taking place (i.e., a 'hot topic' in the journal), and not as encouragement of gratuitous self-citation.

The lack of evidence indicating author influence seems surprising, especially given the relatively high correlation (0.42) in Table 3, but is unequivocal. The h-indices of both the first author, and of the co-author with the highest h-index were examined, but neither offered an improvement to Equation (1). Evidently the author effect is subsumed within the other variables, partly through wise placement of contributions (Albuquerque et al 2011) (i.e., a suitable journal with high TRIF and discussion 'thread' as revealed by journal self-cites), and partly through rejection rates that are correlated with TRIF (Aarssen et al 2008) (i.e., inexperienced authors may experience higher rejection rates, not visible in this study concerned with published material). The good news for novice authors is that once published, articles appear to stand on their merit (TRIF, review content, length, journal self-cites), and not on the extent of the author network (h-index, number of authors).

Perhaps the best single thing an aspiring author can do to attract citations is to participate in a rigorous review rather than writing a conventional research article. However, Ketcham and Crawford (2007) caution against hasty reviews, pointing out that inferior reviews are not well cited, and hamper rather than assist a discipline – and conclude with sage advice for preparing effective reviews that is consistent with other guides (e.g., Montori et al 2003, Derish and Annesley 2011).

Conclusion

Despite well-documented flaws in the Thomson-Reuters impact factor, it remains a strong indicator of journals likely to facilitate a high citation rate. Authors seeking to be well cited should aim to write comprehensive and substantial review articles, and submit them to journals with a high impact factor that carry previous articles on the topic. Notwithstanding this advice, strategic placement of articles is complementary to, and no substitute for careful crafting of good quality research. Authors pursuing this advice are reminded that citation rates are just one aspect of successful research impact. Evidence in the present data remains equivocal regarding the contribution of an author's prior publication success (h-index) and the utility of open-access journals.

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